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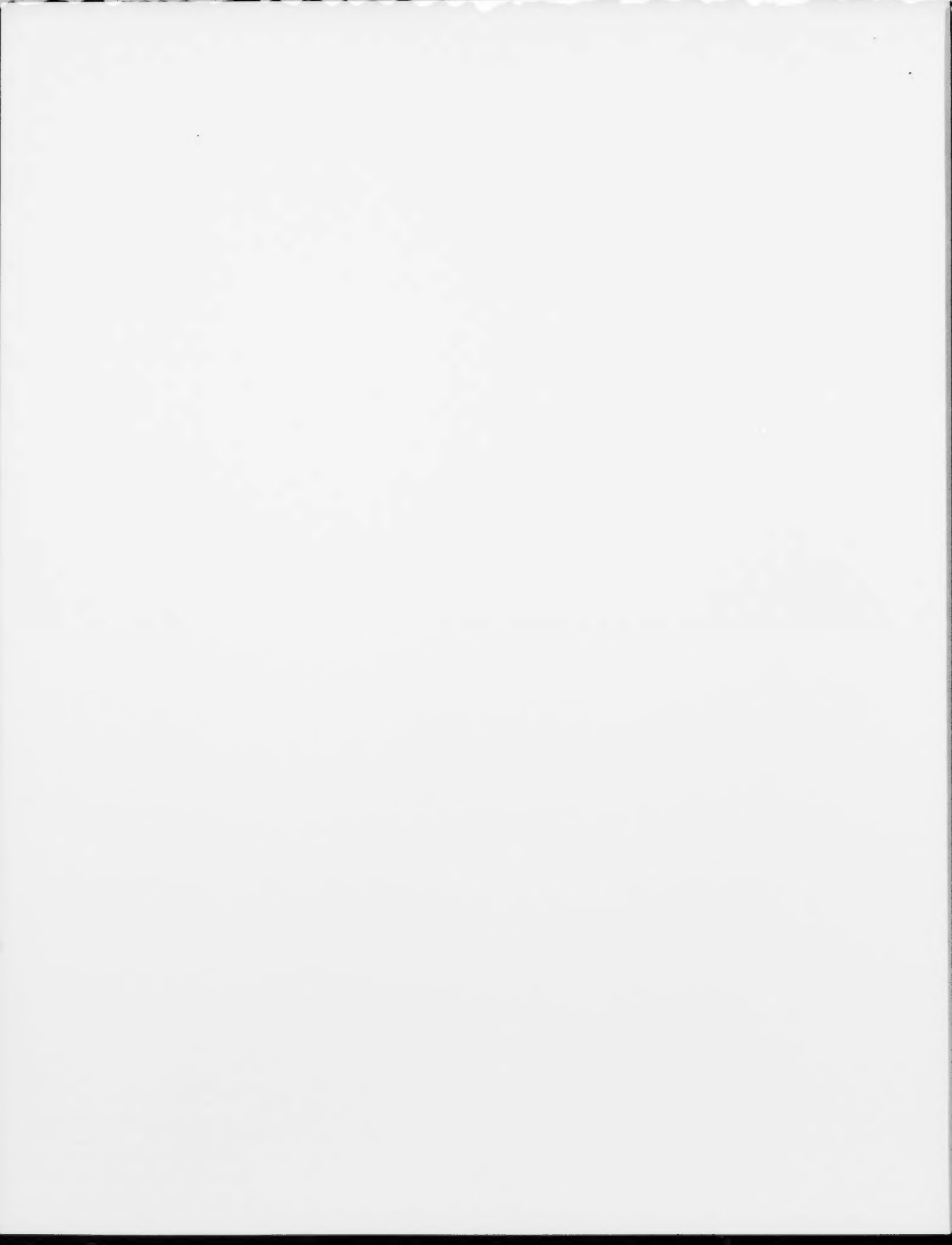
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**BUILDING A NEW OILSEED FLAX STRAW VALUE CHAIN
AT THE FARM LEVEL: PROOF OF CONCEPT**

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Building a New Oilseed Flax Straw Value Chain at the Farm Level: Proof of Concept

REVISED Final Report

Biolin Research Inc.

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Project Title: Building a New Oilseed Flax Straw Value Chain at the Farm Level: Proof of Concept

Biolin Research Inc. gratefully acknowledges the financial support provided by the Agriculture Development Fund of Saskatchewan Ministry of Agriculture. Biolin is particularly grateful to Dave McDonald, Randy Cowan, and its staff members for their efforts in helping to implement this project and to the farmer cooperants and custom operators who participated in this project.

Building a New Oilseed Flax Straw Value Chain at the Farm Level: Proof of Concept

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Abstract/Summary

In the last ten years, research work done by Biolin Research in small plots and small fields has shown it is possible to produce retted flax fibers in Saskatchewan. Fibers from retted Saskatchewan sourced straw have been sent overseas and foreign buyers and potential users have been surprised and often impressed by the quality of the fiber. Given this positive outcome, the next stage in development of industries based on the production of higher end flax fibers is scaling up to full size fields in a variety of Saskatchewan locations to see if the field protocols and methods that Biolin has used in the past are robust enough to give good results under a spectrum of growing conditions at a variety of locations

Objectives

Field scale "proof of concept" testing of a technology package that could:

- 1) produce oilseed flax that has the potential to be processed into mid and higher value fiber and shive,
- 2) be commercially feasible at a field scale level, and
- 3) show potential investors that higher quality oilseed flax straw can be produced on a large scale if a higher end processing plant is set up.

Results

This project:

1. Produced a set of recommendations of what worked and did not work and suggestions of how to improve the methods and protocols that were tried;
2. Gave farmer cooperants in five locations experience in managing oilseed flax straw for higher end uses; and
3. Produced over 200 tonnes of well-retted oilseed flax straw with commercially accepted levels of fiber content under a variety of field conditions using commonly available farm equipment.

Conclusions

The basic methods and protocols used by Biolin shows great potential to produce retted straw in Saskatchewan conditions, however, for it to be really effective and consistent over a wide range of weather and field conditions, several improvements need to be made before these techniques and protocols can be recommended to commercial straw processors. The required improvements include:

1. Finding a better method of getting the straw flat on the ground in a thin layer.
2. Modifying V-rakes so they rake up all the straw which covers all the ground they pass over
3. Using a variety of methods to get the flax crop planted earlier in the spring and harvested earlier in the fall so that there is more time for retting in the fall.
4. Find ways to use over-retted straw and/or to have crop insurance that would cover the risk of over-retted straw.

Introduction

Background

Farmers in Saskatchewan seed 350,000 to 450,000 ha of oilseed flax every year to produce seed that is primarily used for export. Between 500 to 5,000 kg/ha of straw could be collected after the seed is harvested. Only 10-15% of this straw is salvaged and used in manufacturing. The most common products made out of this straw are specialty papers and plastic composite items. The flax straw that is not removed from the field for these uses is normally burnt or chopped and spread. Unfortunately burning has negative environmental impacts and chopping and spreading has an economic cost.

There is increasing interest in utilizing the flax straw that is presently uncollected. Recent market surveys and on-going research indicate that there are many potential products that could utilize flax fibers to complement or replace glass, synthetic and cotton fibers. If flax fibers were used more extensively in such products, it would increase the demand for flax straw, reduce the amount of flax straw that is burnt, and increase farmers' income from growing flax.

For many decades, farmers and processors did not try to extract higher value fibers out of flax straw because they believed optimum retting conditions did not exist on the Prairies and hence there was no point trying to produce higher quality retted flax fibers. In the last ten years, research work done by Biolin Research in small plots and small fields has shown it is possible to produce retted flax fibers in Saskatchewan. Fibers from retted Saskatchewan sourced straw have been sent overseas and foreign buyers and potential users have been surprised and often impressed by the quality of the fiber. Given this positive outcome, the next stage in development of industries based on the production of higher end flax fibers is scaling up to full size fields in a variety of Saskatchewan locations to see if the field protocols and methods that Biolin has used in the past are robust enough to give good results under a spectrum of growing conditions at a variety of locations (i.e., do these techniques need some further improvement before they can be recommended for wide scale use?). To help answer this question, this project carried out proof of concept testing to see if recently developed protocols and machines can be used to consistently produce retted flax straw in Saskatchewan conditions and/or or if these protocols and machines need further improvements.

Rationale

Foreign flax straw processing companies and private investors are very interested in the results that have been achieved in small scale plots but do not want to build new plants in Saskatchewan until they are assured that Biolin's newly developed straw management techniques can be effectively carried out by farmers with full size equipment to produce retted flax straw on many thousands of acres in a wide spectrum of growing conditions. Hence we need to show either that the new oilseed straw management systems that have been developed, can be scaled up to a full field scale level throughout the major flax growing areas of the province or that more work needs to be done to improve these new straw management methods so they can evolve to the point where they can be counted on to produce good retted straw every year.

If this project is successful, it will have a very positive influence on helping raise capital and investment needed to have a number of mid and higher end flax straw processors set up in the province. This, in turn, will:

- 1) reduce the burning of flax straw,
- 2) increase farmers net incomes from flax straw production,

- 3) greatly increase value adding activities (i.e., primary and secondary level processing) based of flax straw, fiber and shive in the province,
- 4) create numerous new jobs in rural areas, and
- 5) increase the tax base in rural areas.

Objectives

Field scale "proof of concept" testing of a technology package that will:

- 4) produce oilseed flax that has the potential to be processed into mid and higher value fiber and shive,
- 5) be commercially feasible at a field scale level, and
- 6) show potential investors that higher quality oilseed flax straw can be produced on a large scale if a higher end processing plant is set up.

Deliverables

- 1) A set of field case studies of what worked and did not work and recommendations for commercial processors who wish to set up in the province
- 2) Farmer cooperants in five locations who have experience managing oilseed flax straw for higher end uses
- 3) Well managed flax straw (600 to 1,000 tonnes) that can be used for commercial scale testing and to help lure higher end flax straw processors to set up in the province

Methods Used

- 1) Selected five locations with at least one cooperating farmer at each location who had an 80 to 160 acre field to plant flax on
- 2) Arranged for the farmer cooperant to plant an oilseed variety that has shown superior fiber and seed yielding ability (e.g., Bethune and Taurus were selected because these were already very popular with farmers and they both have above average fiber content in good growing conditions)
- 3) Got farmer cooperants to use about 40 kg/ha of seed with a strip of 80 kg/ha (i.e., double normal rate) seed in the field.
- 4) Seed was planted with the seeding implements farmers normally used for their flax and other crops to see what negative effects, if any, might be experienced if there was not change in seeding implements
- 5) Cooperants sprayed for weeds in the manner and with the products they normally use to control weeds
- 6) Technicians from Biolin Research collected representative samples in late August to test for fiber content to make sure the straw had a fiber content high enough to warrant the proposed Biolin protocols to produce retted straw

- 7) For fields with minimal weeds and higher than 12% fiber, fields were cut straight or stripped so that straw did not go through the combine and remained as tall as possible standing in the field
- 8) After straight cutting or stripping with a combine, the standing straw was rolled with a land roller in two different directions to form a thin flat layer of straw that touches the ground so it can ret
- 9) When the straw was optimally retted (all fields took till early spring for this to happen because the fields were harvested relatively late in the fall), the straw was raked with a V-rake, baled into small square or round bales and the bales were transported to the edge of the field where they were put in stacks or rows
- 10) During the growing season, harvest season and raking and baling periods, staff from Biolin Research visited the fields to monitor progress and to educate, liaise and discuss with farmers and contractors: field progress, straw quality, degree of retting, problems encountered, lessons learned, etc.

Results

1. Heavier seeding rates often did not result in higher seed or straw yields but did tend to increase weed competition and fiber content. The lack of an increase in straw yield is, in many cases, probably due to farmers using a narrow row opener. When higher seeding rates are used, more plants are packed together in a narrow row with little chance to develop their full potential. From previous plot work, it is probable that heavier seeding rates are only beneficial to increasing straw yields if the row opener is two or more inches wide such that it produces a "ribbon" of seed two or more inches wide.
2. Producers were impressed with the stripper header and believed that there was a great deal of potential for expansion of this method of harvesting flax in Saskatchewan. The following are several examples of these type of positive experiences:
 - In Churchbridge, the cooperator did not have a significant yield difference between single and double seeding rates but the double seeding rate had reduced weed seeds and dockage. Due to the heavy stand, the farmer had a great deal of difficulty straight cutting the heavy seeded flax but had no problem using a stripper header to harvest the heavy seeded flax.
 - The cooperator near Laird had, in total, a 280 flax field. At harvest, he swathed most of it but left some for straight cutting and some for stripping. After he harvested some of the swathed field, a month of rainy weather delayed any further harvest until several sunny windy days in late October. These drying days were not enough for his swaths to dry out or for the flax to be dry enough for straight cutting. It was, however, dry enough for stripping and the farmers was able to get that portion of his field stripped and dry seed in the bin before the snowfall. The swathed and straight cut portions of the field had to remain till spring.
3. In the fall of 2006, some of the fields received over seven inches of rain in four weeks, broken up with regular periods of warm sunshine. This created ideal conditions for retting and much of the straw that was harvested after these rains was partly or totally retted while the plants were still standing prior to seed harvest. In several cases, a small percentage of the stems actually rotted off at ground level. These rotted stems got picked up by the stripper rotor and wrapped around the rotor. This was particularly a problem on damp days when the ground was still wet. Under such a situation, the combine operator had to stop at least

once an hour to untangle the mess of stems. After several days of such struggles, it was found that the best solution was to just wait another day for the ground and straw to dry a little more before using the stripper header. When the straw and ground were dry, there were no wrapping problems.

4. After raking, several rows of retted flax straw, a farmer cooperant near Oxbow experienced a plow wind that blew most of the swaths into a adjacent road ditch. Retted raked flax straw would be very vulnerable to strong winds because it is not anchored into stubble (i.e., the windrows are sitting on bare ground), however, usually baling can take place within 24 hour of the straw being raked (i.e., usually the straw would be vulnerable to wind for less than 24 hours)
5. Most V-rakes in use have a four foot gap in the middle of the rake that allows the windrow to pass out the back of the rake. This is normally not a problem in situations where the windrow sits on top of stubble because the baler will pick up the straw in this "gap" as it picks up straw from the windrow. In our situation, where we do not have stubble, the baler teeth cannot reach the straw in this four foot gap because the straw is lying directly on the ground. Hence, this straw is missed and will tangle up in machinery used in subsequent field operations. To avoid this, at least one harrowing operation must be done to collect this unraked straw for burning or other disposal. This takes extra time and machinery that neither the farmer or the contractor wants to spend.
6. Most of the straw that was rolled, broke off at ground level, however, some kept standing even after being hit twice with a roller. In the spring some of the straw that had not been knocked down with the roller was still standing. The standing straw was, in most cases, not as retted as the straw that had been flattened on the ground the previous autumn. This, in turn, meant that some fields had patches or areas of straw where less than optimal retting had taken place. This was particularly a problem in one field that had a relatively low plant stand on sandy land. The straw that got knocked down in the fall ended up being over-retted and packed tightly against the ground, after rainy weather in the spring. The straw that did not get knock down ended up being only slightly retted by spring. This extreme difference in the degree of retting coupled with the low plant stand resulted in the field being abandoned in the spring because of the very low potential economic value of the straw relative to the cost of baling and the physical difficulty of baling the packed down straw.
7. All straw was eventually raked, baled and stacked. However, some of the fields produced much more consistently retted straw. Most of the difference in the degree of retting was due to the inconsistent knocking down of the straw by the roller in some parts of some fields.
8. Farmer cooperants and staff of Biolin Research learned much about trying to produce good quality fiber from oilseed flax. These farmers had little or no experience of even exposure to such an idea before they started working on this project. Since starting on this project, all of them have developed opinions about what works and what doesn't work and what they would do different to produce better and/or faster results next time. This has been a great learning experience for them and the staff of Biolin Research. We have used this experience to build up subsequent recommendations to further improve the management practices that can be used to improve the quality of fiber that can potentially be produced from oilseed flax straw. All the farmers we worked with have said they would be willing to work again on such activities.
9. Over 200 tonnes of well-retted, relatively high fiber content bales of oilseed flax straw were produced using large-scale field machinery. Heavier than normal rains in early spring just before the straw was to be baled caused over-retting and abandonment of two fields. More than normal rainfall over a one-month period in the fall also reduced the amount of acres farmer cooperants had time to strip and roll in the fall.

10. A variety of measurements were taken during and after the growing season from the fields involved in these trials and the resultant straw produced. These results are shown in Appendix I.

Conclusions and Recommendations

The basic methods and protocols used by Biolin shows great potential to produce retted straw in Saskatchewan conditions, however, for it to be really effective and consistent over a wide range of weather and field conditions, several improvements need to be made before these techniques and protocols can be recommended to commercial straw processors. The required improvements include:

1. Finding a better method of getting the straw flat on the ground in a thin layer. A land roller is cheap and fast but the sections of roller are often at least 12 feet long. If the field has uneven topography or ruts, the roller does not hit all of the straw at the right angle and hence not all the straw breaks off. This produces uneven retting and hence inconsistent quality fiber which must be sold for a discounted price relative to prices that consistently retted fiber can command. More flexible rollers and/or wide, robust mowers should be investigated as alternatives to rolling.
2. The V-rakes that are used must have wheels attached behind or in front of the gap in the rake or even in front of the tractor so that the straw in the four-foot gap in the center of the rake is also raked and becomes part of the windrow. Although a tetter rake was not tried, it could also have the same problem, unless all of the ground is raked as the machine moves over the ground.
3. Using a variety of methods to get the flax crop planted earlier in the spring and harvested earlier in the fall so that there is more time for retting in the fall and hence so that a good portion of the retted straw can be baled in the fall.
4. Stripper headers have greater potential than swathing or straight cut systems to speed up the harvest and allow a farmer or contractor to get the stripped tall flax straw flat on the ground in a thin layer earlier in the season and hence to have retting take place earlier and hence to have retted straw off the field earlier. However, for this to happen, stripper headers probably need to be mounted on combines that specially harvest flax as early in the harvest season as possible. Having a stripper header but using it only when all the other crops are harvested (i.e., flax is traditionally harvested last by many farmers) will not generate nearly the benefit (i.e., early and faster retting) that stripping early in the harvest season will. Such dedicated flax harvest combines could be owned by private contracts or by the processing plant and could just harvest flax crops that have straw with the potential to produce good fiber. Such contract harvesting of flax would not only get more flax acres off earlier and allow a much bigger area of earlier retting; it would also reduce the workload of farmers in the autumn and give them more time to do other work. Hence the straw would be retted sooner (and hence have more value) and the farmers would have more free time. Such a custom flax combining operation hence has the chance to be a "win-win" situation.
5. Our experience in this project has shown that prolonged and/or heavy rains in the spring can cause over-retting and abandonment of what would otherwise be well-retted flax straw. From time to time this also happens in Europe where farmers have been producing flax fiber for textile use for hundred of years and is considered a risk that is covered by crop insurance. In the future, if the flax straw industry sees further development, this would hopefully be a risk that Crop Insurance would insure for. In the future, there should also be some research and development work done in the area of how to best process and use over-retted flax straw.

Acknowledgements

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Literature Cited

No literature has been cited in this final report, however, some relevant publications cited in the original letter of intent include:

Ulrich, Alvin; Marleau, Richard and Palmer, Tricia. Flax 2015 Fiber Pre-feasibility Study. Prepared for the Flax 2015 Fiber Pillar Working Group, Saskatoon, March 2005.

Ulrich, Alvin and Marleau, Richard. *Using Agronomic Practices to Increase the Per Hectare Yield of Flax Fiber*. 91st Annual Meeting Preprints – Book A. Pulp and Paper Technical Association of Canada, Montreal, February 2005.

Ulrich, Alvin. Developing a Sampling Protocol to Enhance the Profitability of Flax fiber Processing. Proceedings of the International Conference of FAO European Research Network on Flax and Allied Fiber Plants for Human Welfare, National Research Council, Cairo, Egypt, December 2003.

Other

Photographs were taken of various field operations and of the resultant straw bales and stacks. These are available from Biolin Research upon request.

Appendix I

Summary of Fields and Field Operations

Name	Acres of Flax Seeded, Baled and Rolled	Comments
Duanne Bigney Oxbow	Acres Seeded: 140 Acres Rolled: 100 Acres Raked: 8 Acres Baled: 0	Rolling and retting very successful; shortly after raking started in spring, a prolonged rain caused over-retting and abandonment of raking and baling effort
Jarvis Blushki Langham	Acres Seeded: 55 Acres Rolled: 55 Acres Baled: 0	Thin stand; straw retted very unevenly because not all straw knocked down by roller in fall; extreme unevenness of retting combined with the low straw yield resulted in a decision to abandon the field because of the potential low economic value of the straw relative to the cost and difficulty of baling
Warren Keating Churchbridge	Acres Seeded: 40 Acres Rolled: 30 Acres Raked: 30 Acres Baled: 30	The stripper header harvested thick straw that could not be straight cut; straw partly retted standing up awaiting harvest. Retting might have been better if rolled in the fall.
Allan Klassen Laird	Acres Seeded: 230 Acres Rolled: 65 Acres Baled: 65	Part of field swathed, part straight cut, part stripped, because of prolonged rain, was only able to strip in mid October, straw almost finished retting before harvest.
Arnold Klassen (AK) Rosthern	Acres Seeded: 240 Acres Rolled: Acres Raked: 0 Acres Baled: 80	Substituted straw for Bigney's abandoned straw; standing retted straw baled directly after being combined in May
Leonard Thiessen Hepburn	Acres Seeded: 60 Acres Rolled: 60 Acres Baled: 60	Straw almost finished retting before harvest; stripping slow because of small combine that was used.

Straw Yields

ADF20050742 - Building a New Oilseed Flax Straw Value Chain at the Farm Level: Proof of Concept																		
Data for Final Report																		
field	seeding rate (density)	seeding spacing / a	variety		Soil Zone (Source: SAF)	Plant Ht with seeds (cm) /b /j	Cut Straw Length /c /j	Plant Count per m2 /j	Fiber % On Unretted Straw (NIR) /e /j	Salvaged Straw Yield(kg/ha) /f /j	Fiber Yield (NIR) of collected sample based On Salvaged Straw (kg/ha) /g /j	Seed Yield (kg/ha) /h /j	Seed Yield (bu/ac) /i /j	Acres Baled	# of Bales	Type of Bale	Avg Wt per bale (kg)	Actual Straw Yield (kg/ha) /k
Bigney	single pass	12 inch	Bethune	Moist Dark Brown	69	44	507	18.4%	2,237	412	1,251	20	N/A					
Bigney	2x pass	12 inch	Bethune	Moist Dark Brown	70	46	843	17.5%	2,974	522	1,466	24						
Blushki	light	8 in	Bethune	Black	61	33	101	19.0%	665	127	726	12	N/A					
Blushki	heavy	8 in	Bethune	Black	58	34	213	21.1%	610	129	563	9						
Keadung	light	10 in	Taurus	Moist Black	75	49	482	18.3%	2,553	467	1,753	28	80	50	Round	455	702	
Keadung	heavy	10 in	Taurus	Moist Black	66	44	542	17.7%	2,361	418	1,734	28						
Klassen	light	7 in	Bethune	Black	71	48	393	23.3%	2,252	524	2,037	33	80	132	Round	455	1,854	
AK	light	10 in	Bethune	Black	did not measure in Aug 06								80	64	Round	455	899	
Theizen	light	9 in	Bethune	Black	61	40	450	20.6%	1,670	344	1,247	20	80	1226	Square	18	681	
NOTES																		
a/ Samples were taken at 25 cm lengths from a row (Calculated to be number of lengths in the seed row spacing)																		
b/ Plant Ht with Seeds (cm) is measured from the ground level to the top of the average heights of plants with seeds																		
c/ Cut Straw Length (cm) is measured by cutting the straw at the level the seed boll heads and holders start																		
d/ Salvaged Straw Wt (g) is the weight of the cut straw after cutting the straw at the level the seed boll heads and holders start																		
e/ NIR Fiber % On Unretted Straw is the amount of fiber, expressed as a percentage, within the NIR scanned sample scanned on a FOSS																		
f/ Salvageable Straw Wt (kg/ha) is the 'Salvaged Straw Wt (g)' times 10,000 m2 per hectare divided by 1,000 grams per kilogram																		
g/ Fiber Yield Based On Salvaged Straw (kg/ha) is the 'Salvaged Straw Wt (kg/ha)' times the 'NIR Fiber % On Unretted Straw'																		
h/ Seed Yield (kg/ha) is the clean seed from 1m2 from the gathered sample times 10,000 m2 per hectare divided by 1,000 grams per																		
i/ Bushel per acre is based on 25kg per bushel and 2.47 acres per hectare																		
j/ Based on samples collected August 2006																		
k/ Based on estimated weight of straw baled in spring																		

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